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DISCOVERY OF *SOLIDAGO PORTERI* (ASTERACEAE: ASTEREAE) IN ALABAMA AND TENNESSEE AND A SECOND POPULATION IN GEORGIA

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ABSTRACT

Solidago porteri Small was thought to be known only from the type collection from Monticello in Jasper Co., Georgia, in the southeastern U.S.A. In 2003, a collection that is now recognized to be the same species was made in Hartselle in Morgan Co., Alabama. In 2004, a collection that is also now recognized to be the same species was made in Giles Co., Tennessee. Exchange of information between the authors resulted in additional material being collected at the Tennessee site in 2012. A review of photographs of types at NY revealed that the Alabama and Tennessee collections were recent collections matching the type material of *S. porteri*. Both the Alabama and Tennessee collections were determined to be hexaploid $2n = 27_{II}$. A search for additional collections in the GA herbarium in 2014 yielded a set of *S. porteri* plants from Morgan Co., Georgia. Details of the morphology and distribution are discussed.

Solidago porteri Small was described in 1903 from a T.C. Porter collection made in Monticello (Jasper Co.), Georgia, in 1846. Figure 1 shows a previously unrecognized isotype, *Porter s.n.* (NY; Thiers 2014). Guy Nesom annotated the specimen as *S. buckleyi* Torr. & A. Gray in 1990 (see Semple and Gandhi 2012), and J.C.S. included the specimen in an unpublished multivariate study of *S.* subsect. *Thyrsiflorae*, before its correct identity was known. The attached note on the specimen indicates that A. Gray and Canby also had trouble with identifying the collection in the 1800s. Cronquist (1980, p.122) included the following statement about *S. porteri* under *S. hispida* Muhl.: "Known only from [holotype] type collection, suggests a robust form of *S. hispida*, but less hairy (stem glabrous below, rather sparsely spreading-hirsute above) and has a somewhat wider and looser inflorescence. The proper disposition of this name is uncertain." Semple and Cook (2006) in Flora North America treated the species as a synonym of *S. erecta* Pursh, based on the type having similar variation in stem hair distribution as well as typical subsect. *Squarrosae* traits of large lower stem leaves and a club/wand shaped arrangement of heads.

In 2003, a single individual was collected along a roadside just south of Hartselle, Alabama. Three shoots were pressed (*Semple & Semple 11190* WAT; Fig. 2) and involucre buds were fixed for later chromosome counting from meiotic figures. No photographs were taken in the field and the plant was labeled *Solidago petiolaris* Ait. var. *petiolaris* because the plant was nearly a meter tall and had multiple stems developing from the rootstock. Traits of the specimen were scored for a multivariate study of *Solidago* subsect. *Thyrsiflorae* A. Gray, but J.C.S. later realized that the

collection did not possess the traits of that subsection. It was subsequently erroneously labeled *S. patula* Muhl. subsp. *patula*. The collection came from the area between the known distributions of *S. patula* and *S. salicina* Ell. (synonym: *S. patula* ssp. *strictula* (Torr. & A. Gray) Semple; see Semple et al. 2012), although the hexploid chromosome count (see below) for *Semple & Semple 11190* was unknown for either of these species of *Solidago* subsect. *Argutae* (Mackenzie in Small) Nesom. The correct identity of the collection as *S. porteri* was not determined until September of 2012 following additional field and herbarium work.

In 2004, a population of what was initially thought to be *Solidago petiolaris* was discovered in Giles Co., Tennessee: *Estes 6795* APSC. Cypselae were taken and planted by D.E in his home garden. Email was exchanged between the authors in 2006 regarding the identification of this collection. When J.C.S. decided in the summer of 2012 that his Alabama collection was possibly a new species in *Solidago* subsect. *Squarrosae* A. Gray, email was again exchanged and field work was planned so that both authors could see the Tennessee population and determine if it was conspecific with the Alabama population, which it was.

On 12 Sep 2012, the Tennessee site was sampled again (*Semple, Estes, Campbell, & Brock 11861* BRIT, GA, DAO, GH, MO, NY, TENN, and WAT, 3 sheets) and then on 13 Sep 2012 (*Semple 11867* MO, NCU, WAT, US), when light conditions were more conducive for taking habitat photographs. The large sample was taken to obtain sufficient specimens for inclusion of the taxon in a multivariate morphometric study of *Solidago* subsect. *Squarrosae* being carried out in the J.C.S. laboratory. Efforts to find other populations in adjacent Lawrence Co. near the Giles Co. population were unsuccessful.

The 2003 Alabama site was also visited on 13 Sep 2012 but was not relocated. In 2003, US-31 was a two-lane road and the plant was growing on the road embankment. In 2012, US-31 was a four-lane road and no plants of *S. porteri* were seen. Highway construction apparently extirpated the only currently known location of the species in Alabama. A search along other roads in and around Hartselle failed to turn up another population of the species.

The University of Georgia herbarium (GA) was visited on 17 March 2014 and a search of *Solidago* collections was made to find additional specimens of *S. porteri*. No specimens were filed under the name *S. porteri*. Folders of *S. bicolor*, *S. erecta*, *S. hispida*, and *S. petiolaris* were examined but did not include specimens of *S. porteri*. A folder labeled "Solidago hybrid swarm" was examined and this contained four specimens of *S. porteri* from north of Rutledge, Morgan Co., Georgia: *J.W. Hill 1162a* (GA); *J.W. Hill 1162b-1* (GA; two sheets; Fig. 3); and *J.W. Hill 1162c-6* (GA). These came from "open pine woods," "mature hardwoods," and "open sunny near lake [Lake Rutledge]" on 6 September 1979. Morgan County is just north of the type locale in Jasper Co., Georgia. Heads of these specimens were in bud stage to mature fruiting stage. The Hill collections indicate that the species had survived in this part of the Georgia Piedmont for 137 years. The lack of other recognized collections of *S. porteri* from the area or elsewhere in Georgia is probably indicative of the rarity of the species. In Alabama the species is known from only one site, where now extirpated. In Tennessee the species is known from a single population consisting of fewer than 50 individuals.

Physiography

Both the Alabama and Tennessee populations of *Solidago porteri* are/were situated within the Interior Low Plateaus Physiographic (ILP) Province. The Tennessee site (Figs. 4-6) is in the Western Highland Rim Subsection, Highland Rim Section of the ILP. This area is primarily underlain by Mississippian-aged cherty limestone of the Fort Payne formation. Historically, this area was dominated by a mix of native grassland and oak savanna, areas often referred to as barrens. These

barrens, which were restricted mostly to the broad, flat uplands are common to portions of western-most Giles Co., much of adjacent Lawrence Co., extreme southwestern Maury Co., and parts of southeastern Lewis Co. Today, remnants of this once extensive barrens vegetation are found mostly along roadsides and include typical species such as *Andropogon gerardii*, *Schizachyrium scoparium*, *Sorghastrum nutans*, *Helianthus eggertii*, *H. silphioides*, *Tephrosia virginiana*, numerous species of *Lespedeza*, *Desmodium*, and *Liatris spicata*. Much of this region has succeeded into oak-hickory woodland and the presence of scrubby post oaks and blackjack oaks, the typical oaks of the barrens, is a further indication of the once former grassland/savanna physiognomy. A large amount of the wooded landscape has been timbered at least a couple of times and much of it has been converted to loblolly pine (*Pinus taeda*) plantations, a species which is native only a few miles to the south in northern Alabama. Clearcuts are abundant in the area and many of the clearcuts contain numerous barrens species soon after harvest. Much of the area not in woodland has been extensively cultivated in cotton and soybeans.

In addition to *Solidago porteri*, other rare barrens species found in southwestern Giles Co., Tennessee, include *Bradburia pilosa* and *Helianthus eggertii*. For the *Bradburia*, this is the only region of Tennessee where it is known to occur. *Helianthus eggertii* is endemic to the Highland Rim barrens of the Interior Low Plateau of south central Kentucky, Tennessee, and northern Alabama. The barrens are mostly dry, but wet barrens undoubtedly once were more extensive in the region as well. *Solidago porteri* grows in dry soil at the margin of a ca. 10-year old clearcut that has been planted in loblolly pine monoculture. The pines are so dense and have grown so much since the discovery of *Solidago porteri* in 2004 that the goldenrod is actually in danger of being shaded out at this locality.

The Alabama site is also located in the ILP but is 75 km south-southeast of the Tennessee, population. It occurs very near the border of the Little Mountain portion of the ILP and the Moulton Valley, which is considered a lobe of the Eastern Highland Rim Subsection, Highland Rim Section of the ILP. The Little Mountains are a small, east-west trending ridge system that extends for ca. 112 km of northwestern Alabama across portions of Colbert, Franklin, Lawrence, and Morgan counties. The geology of the LM is primarily Mississippian sandstone, underlain by Mississippian limestone. Most of this ecoregion is currently wooded or in pasture. The Moulton Valley parallels the Little Mountains to the south and is sandwiched between the Little Mountains and the Cumberland Plateau. This limestone valley, of Mississippian age, is mostly flat and is characterized by many limestone cedar glades.

Moulton Valley supports a wide range of species, including those with calcareous and acidic preferences, dry prairie and glade species, and wetland species. The collections from Hartselle were collected in an oak savanna, a habitat that is quite similar in some respects to the Tennessee site, which would have historically been oak savanna or oak barrens, as they are often called. The Moulton Valley is known for containing a number of endemic plant species. The limestone glades there support a number of rare and restricted species, including several not known to occur outside of the Valley. These include *Leavenworthia crassa*, *L. alabamica*, *and Sisyrinchium calciphilum.*

A few rare plant species make similar range disjunctions between southwestern Middle Tennessee barrens and similar habitats in northwestern and north-central Alabama. *Helianthus eggertii* and *Silphium mohrii* both are endemic or nearly so to Highland Rim grasslands and occur in these two major regions. A new and highly restricted species of *Lysimachia*, under study by D. Estes, also makes a similar jump. Ninety-five percent of this taxon's worldwide range is restricted to the dry-xeric oak woodlands of eastern Lewis Co. and extreme southwestern Maury Co, Tennessee. From these populations the species jumps southward to the oak woodlands in Blount Co., Alabama, in the southern Cumberland Plateau. *Solidago porteri* makes a similar jump from south-central

Tennessee to north Alabama region and additionally jumps to the Georgia Piedmont, with its type locality located near Monticello in Jasper Co., and the 1979 collections from Morgan Co., Georgia.

While the odd distribution of *Solidago porteri* raises phytogeographic questions, other species have somewhat similar patterns of disjunction. The rare whorled sunflower, *Helianthus verticillatus*, is found in two localities in the Coastal Plain of southwest Tennessee and is disjunct to the Coosa Valley of northeastern Alabama and northwestern Georgia and is known from nowhere else. Likewise, *Silphium mohrii* is found discontinuously in a crescent-shaped arc extending from south-central Tennessee through northern Alabama to northwestern Georgia's Ridge and Valley and Cumberland Plateau provinces.

Morphological comparisons

Solidago porteri is a member of *Solidago* subsect. *Squarrosae* with similiarities to *S. hispida* but has noticeably larger heads with more showy rays. Collections from the four known populations sampled were initially identified as members of subsect. *Thyrsiflorae*, either as *S. buckleyi* (Fig. 1) or *S. petiolaris* (Fig 2A) or as samples of a hybrid swarm without parents designated (Fig 3A). The robust size of the some plants with multiple stems and the sometimes large lower and mid stem leaves with serrations (Figs. 1C,E and 2A) are traits of *S. buckleyi* and sometimes *S. petiolaris*. The inflorescence (Figs. 2A, 3A and 4E) can be similar in appearance to that of plants of *S. arenicola* Keener & Kral, which is native to northern Alabama and northern Tennessee and adjacent Kentucky and is a member of *Solidago* subsect. *Humiles* (Rydb.) Semple. This is likely convergence due to the larger involucres (Fig. 5) of the two polyploid species. No resin or glands typical of species of subsect. *Humiles* were observed on any of the collections of *S. porteri*. The largest leaves are basal (Fig. 3A), which is typical of subsect. *Squarrosae*, but not subsect. *Thyrsiflorae*. Rosettes were observed at the Giles Co., Tennessee, site in 2012 but were rare. These did not appear to be produced from lateral branches of rootstocks that bore flowering stems, which is a common growth form in subsect. *Squarrosae*.

Preliminary results of the unpublished multivariate study by J.C.S. and his students are significant. A stepwise discriminant analysis was used to generate a discriminant function for placing specimens a posteriori into the a priori species level groups using a combination of leaf and floral traits. All eight specimens of *Solidago porteri* were placed into *S. porteri* and seven of these were placed in *S. porteri* with 97-100% probability. The only other species whose specimens were placed as strongly a posteriori into its priori group was the very distinctive *S. villosicarpa* LeBlond. In the plot of canonical variate scores, *S. porteri*, *S. villosicarpa*, and *S. squarrosa* Muhl. were separated on the first and second axes from all other species in the subsection. Additional work is needed to complete the multivariate study. Preliminary results indicated that *S. porteri* is a morphologically very distinct species in spite of the fact that is has been misidentified or placed in synonymy by nearly everyone, including the authors, until now.

Chromosome numbers and cytological observations

The following two chromosome counts by J.C.S. were determined from pollen mother cells undergoing meiosis. The methods were those described in Semple & Cook (2004). In addition, anther sacs of *Semple et al. 11861* (same population as *Estes 06795*) were examined from head buds fixed in the field, but these turned out to be male sterile. No pollen mother cells or mature pollen were observed in multiple floret buds dissected.

Solidago porteri Small. $2n = 27_{II}$. **USA. Alabama**. Morgan Co.: US-31 S end of Hartselle, 4.7 km S of US-36, oak savannah in area with houses, 5 Sep 2003, *J. Semple & B. Semple 11190* (WAT).

Solidago porteri Small. $2n = 27_{II}$. **USA. Tennessee**. Giles Co.: ca. 4 mi NW of Minor Hill (SW of Paulaski), W side of Little Texas Rd., S of intersection with Kennedy Rd., barren roadside, 30-40 plants present, 21 Aug 2004, *Estes 06795* (APSC; from F1 plant grown in Clarkesville, TN).

Description in Flora North America style (mean values in **bold**)

Plants 34–**67**–104 cm; caudices short branched. **Stems** usually single to 6, glabrous proximally, sparsely to moderately strigose in inflorescence. **Leaves**: proximal most withering, smaller; basal and proximal cauline tapering to winged petioles, blades elliptic to elliptic-obovate or oblanceolate, mostly 46–**94**–150 × 14–**23**–53 mm, margins serrate, 1–7–17 serrations per side, usually acuminate, glabrate or sparsely strigose on the adaxial surface, sparsely to moderately strigose on the veins and abaxial surface; mid and distal cauline sessile, blades mostly rhombic-elliptic to narrowly lanceolate, mid cauline 38–**65**–153 × 9–**16.5**–38 mm, upper cauline 20–**35**–65 × 6–**9.7**–18 mm; margins becoming less serrate on more distal leaves. **Heads** 5–75, in elongate, narrowly paniculiform arrays, 30–220 mm long, leafy-bracteate proximally, not secund, proximal branches sometimes elongated and ascending. **Peduncles** 1–6 mm, bracteolate. **Involucres** cylindrical-campanulate, 6–**7.2**–9.5 mm. **Phyllaries** in 3–4 series, appressed, unequal (outer 1/4 length of inner), linear-oblong to lanceolate, apices obtuse to rounded. **Ray florets** 4–**6**.5–8; laminae 2–**3.2**–4.5 × 0.8–**1.4**–2.1 mm. **Disc florets** mostly 9–**11**–15; corollas 3.5–**5.1**–6.2 mm, lobes 1.1–1.9–2.1 mm. **Cypselae** (tan) 1.75–3.5 mm, usually glabrous, sometimes sparsely strigose; **pappi** 3.6–5.8 mm. ***2n*** = 54.

Additional specimens of *S. porteri* are likely hidden away in other herbaria under various names other than *S. porteri*. The multiple images and detailed description included here are provided to aid others in finding these specimens.

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Multivariate Studies in Solidago
Solidago subsect. Argutae
K. Nizamani & J.C. Semple Specimen No
WAT 2012 University of Waterloo
UNIVERSITY OF TEXAS HERBARIUM (LL.TEX)
Solidago buckleyi T. & G.
Det. Guy Nesom, 1990
Solidago porteri Small
Det. John C. Semple University of Waterloo 2012
WAT
ISOTYPE: Solidago porteri Small, Fl. S.E. U.S. 1194, 1339. 1903. TYPE: U.S.A. GEORGIA. Jasper Co.: Monticello, "in dry woods," Sep 1846, Porter s.n. (HT: NY ex Columbia, photo!; ITs: GH!, NY ex Herb. Lafayette College ex College of Pharmacy Herbarium 1970!).
John C. Semple, WAT 4 Oct 2012 University of Waterloo
COLLEGE OF PHARMACY HERBARIUM
DEPOSITED IN 1970
THE NEW YORK BOTANICAL
NEW YORK BOTANICAL GARDEN
Ex. HERB. LAFAYETTE COLLEGE.
Solidago Buckleyi, T&G
Monticello, Georgia.
Legit, Sept. 1846,
THOS. C. PORTER, EASTON, PA.
Sp. veg

Figure 1. A previously unrecognized isotype of *Solidago porteri* Small, *Porter s.n.* (NY).

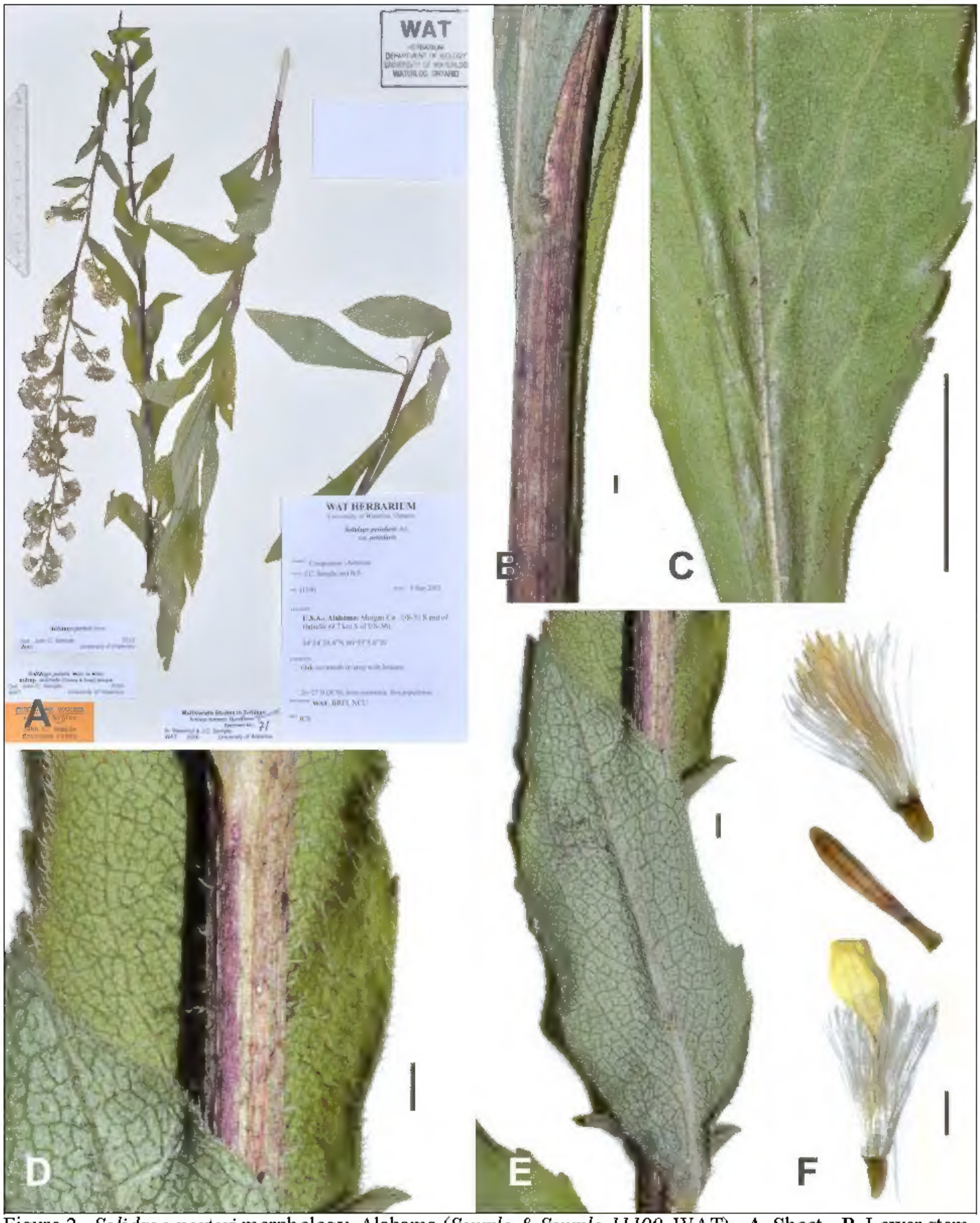

Figure 2. *Solidago porteri* morphology, Alabama (*Semple & Semple 11190,* WAT). **A.** Shoot. **B.** Lower stem. **C.** Lower stem leaf detail, adaxial surface. **D.** Mid stem detail. **E.** Mid stem leaf, abaxial surface. **F.** Ray and disc florets and disc floret corolla (immature). Scale bar = 1 mm in B, D-F; = 1 cm in C.

Figure 3. *Solidago porteri* morphology, Georgia. **A.** Shoot *(J.W. Hill 1162b-1,* GA, sheet 1). **B.** Upper stem and leaf surfaces (*J.W. Hill 1162b-1,* GA, sheet 2). **C.** Fruiting heads (*J.W. Hill 1162a,* GA). **D.** Disc floret cypsela (*J.W. Hill 1162a,* GA). Scale bar = 1 mm in B, D; = 1 cm in C.

Figure 4. *Solidago porteri* habitat in Tennessee of *Semple et al. 11861* and *Semple et al. 11867*. **A.** Habitat looking north. **B.** Habitat looking south along west side of road. Locations of plants indicated by arrows.

Figure 5. *Solidago porteri* morphology, Tennessee (*Semple et al. 11861*). **A.** Shoots. **B.** Mid stem leaves. **C.** Mid stem detail. **D.** Mid stem leaf detail, abaxial surface **E.** Inflorescence.

Figure 6. *Solidago porteri* floral morphology, Tennessee *(Semple et al. 11861)*. **A.** Part of an inflorescence. **B.** Heads showing involucres. **C.** Head showing rays; most disc florets not yet open.